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ON SOME OF THE RELATIONS

OF

Meteorological Phenomena to Man,

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BY

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METEOROLOGICAL PHENOMENA TO MAN.

By John W. Tripe, M.D.

Although this subject has received much attention for many centuries, especially from Hippocrates and numerous other eminent physicians since his time, yet it was impossible for these writers to arrive at reliable results until some legislative enactments had been made for the compulsory registration of deaths. Still, it must not be supposed that in this country a fair approximation to the truth could not have been arrived at long before the Registration Act came into force, because the percentage of total deaths entered in the Parochial Registers appeared to have varied but little in different years. The numbers were, however, only approximative; indeed, as I mentioned in my last inaugural address, Mr. Rickman stated, as the result of careful inquiries, that about one-sixth of the total burials were not returned by the parish clerks. It would, therefore, lead to very erroneous conclusions, if we were to compare the deaths registered under the different orders and classes now, with those published during the last century, not only on account of the imperfection of the returns, but because of the improved means of diagnosis that we now possess. Even now, however, there is plenty of room for improvement, as many deaths are registered on the statements made by unqualified medical practitioners, nurses, and the nearest relatives of the deceased who were present at the death. Some stringent action should be taken to reduce the number of deaths thus registered, especially of young children. There are also other reasons for some allowance being made, if strict accuracy be required, because the assigned causes

are often insufficient to have produced death, or because they were evidently returned as a cover for something to be hidden, as death from child birth. In large numbers these errors do not much interfere with the results, especially if the investigation be a comparison of deaths from similar causes in several years, as the percentages of such registrations probably do not vary to a marked extent in different years. I feel, therefore, that we are treading on tolerably firm ground, when we compare variations of the weather with mortality returns, due allowance being made for certain disturbing causes which will be mentioned in another part of my address.

I do not propose discussing the effects of all meteorological phenomena on man, in the first place, because the subject is much too large for an address, and secondly, because sufficient data are wanting for a complete inquiry into the subject. I shall not enter into the effects of climate (although it will be advisable to refer to some of the causes of different climates), because this word includes not only all the meteorological elements which are classed together under the term "weather," but also the physical peculiarities of the locality in question, such as its nearness to large surfaces of water and to swamps; the nature of the soil, the configuration of the ground, and the extent of forests and other vegetation which modify the climate of a place to a very great extent. Indeed, alterations in the proportion of land covered with water and forests have changed the climates of many countries to such an extent, as to have rendered lands fertile and healthy, which were at one time almost uninhabitable, or to have made unhealthy or sterile, localities formerly healthful and fruitful.

The part played by oceanic currents in making the climate of England temperate and pleasant, instead of being almost unendurable, and indeed, of causing this earth to be habitable over a great part of its surface, is scarcely sufficiently recognised. I trust, therefore, that I shall be excused for referring briefly to this subject, which has been admirably treated in Croll's *Climate and Time.* This writer, who is one of the most trustworthy on this subject, and who has very deeply investigated it, says, that if the heat derived from the Gulf Stream were taken away from the North Atlantic, the surface-water would have a temperature of minus 3°, or 35° below freezing point. That the heat hourly dispersed from the stream would be able, if applied to steam-engines, to develop as much power as would be required by nearly four hundred millions of our largest iron-clad steam vessels. Part of this heat is used in

raising the temperature of the oceans through which the stream passes, and part is absorbed by the air overlying the water, and carried by south-westerly winds over a large proportion of our own country, and the north-western parts of Europe. The capacity of water for heat is very much greater than that of air, as the amount of heat which would raise a cubic foot of water only 1° Fahr., would raise the temperature of 3,234 cubic feet of air to the same extent. We cannot, therefore, be surprised at the great influence assigned to oceanic currents by Croll. Indeed, it is chiefly through the heat given out by the Gulf Stream, that we have in this country green fields and unfrozen harbours during the depth of winter, whilst New Brunswick, Newfoundland, and Labrador, which are nearly in the same latitude as England, but away from the influence of the Gulf Stream, are covered with ice and snow during a considerable portion of the year.

Having made these preliminary remarks I will now pass on to consider the proper subject of my address, viz., the relations existing between man and variations of atmospheric pressure, temperature, and humidity, as well as their influence on disease and death, and shall also briefly allude to the effects of winds, ozone, and electricity on the inhabitants of this country.

Barometric Pressure.—The influence of variations in the atmospheric pressure, at moderate heights or depths above or below mean sea-level, is by no means very marked, except secondarily, as when diminished pressure assists in causing explosions in collieries, or the escape of ground-air into houses; but at considerable elevations, such as at 8,000 feet or more above sea-level, the effects are very decided on most persons. It was at one time considered that much of the discomfort felt on high mountains was occasioned by the expenditure of force in ascending to these heights, but the experience of those who have made ascents in balloons, or who have temporarily lived on high mountains, show that this is erroneous. The sensations felt at great elevations, which are popularly known as "mountain sickness," are very unpleasant, as I can personally vouch for. These may be briefly summarised as follows:—great feeling of malaise; shortness of breath; much loss of strength; palpitation of the heart; nausea, on making very slight exertion, such as taking a few steps up the mountain side; with more or less giddiness and noises in the ears, even when not moving about. I suffered from these symptoms during the ascent of a mountain, at about 10,000 feet and above, but they ceased on reaching the top

and keeping myself still. Some persons suffer much more than others, but after a time nearly all become acclimatised, and capable of taking exercise without unpleasant feelings, as well as of carrying on their ordinary avocations with comparative comfort.

The sensations experienced by Mr. Glaisher during one of his balloon ascents, when he attained a greater height than anyone else has been known to reach, except his companion Mr. Coxwell, may be epitomised as follows. At an elevation of 29,000 feet, when the barometric pressure equalled 9$\frac{3}{4}$ inches of a column of mercury, or less than one-third of the pressure at starting, he noticed that he became unable to distinguish the fine divisions on any instrument, the column of mercury in the wet-bulb thermometer, or the hands of a watch. Shortly afterwards, he laid his arm upon the table, and immediately lost all power to move it, and trying to move the other arm he found that powerless, but was able to shake his body. His head then fell backwards, and he saw Mr. Coxwell in the ring of the balloon. The ability to speak next left, and then total loss of sight occurred, although the brain remained as active as ever. Total unconsciousness quickly ensued. He believes that five minutes elapsed from the first failure of vision to the supervention of total unconsciousness. The first return to consciousness was noted by his indistinctly hearing Mr. Coxwell say "instruments," "observations," after which he gradually regained his sight. Similar sensations occurred in myself whilst inhaling protoxide of nitrogen at a dentist's, as I first lost the sense of hearing, then of sight, and lastly consciousness, which latter returned perfectly before sight or hearing, so that I felt as if I must die unless the pressure were removed from my chest. I knew that I was unable to see, move, or speak. Mr. Glaisher believes the balloon to have reached an elevation of 36,000 or 37,000 feet, during his unconsciousness, but it is noteworthy that Mr. Coxwell at no time became insensible or unable to move. At 19,000 feet, during his first ascent from Wolverhampton, Mr. Glaisher noticed increased rapidity of pulse (100 beats per minute), palpitation, increased sensibility to sound, and difficulty of breathing, followed at 21,800 feet by a feeling like sea-sickness. In other ascents these are not mentioned until an elevation of nearly 24,000 feet had been attained. Many other aëronauts have ascended to an elevation of 23,000 or 24,000 feet without any symptoms of "mountain sickness." The symptoms felt by aëronauts prove that great muscular exertion is not the chief cause of the attack.

The ordinary effects observed amongst those who reside on elevated mountain plateaus are said to be increased rapidity of the pulse to the extent of 15 to 20 beats per minute; quickened breathing, varying from 8 to 12 or even 15 respirations per minute; increased evaporation from the skin and lungs; diminished secretion of urine; and lessened spirometric capacity of the lungs. The diminution in the quantity of the urine is often very marked, even amongst tourists in the high Alps.

The question now arises, do the symptoms described depend simply on diminished pressure, or on the diminution of oxygen in the air breathed? Late investigations of M. Paul Bert have confirmed the opinions of MM. Lombard, C. Martin, and Jourdanet, published in 1861, that all these symptoms, as well as those known as mountain sickness, are chiefly due to the diminution of oxygen in the air inspired, and consequently in the blood. Absolute experiment has shown that the blood of unacclimatised persons contains less oxygen at great than at ordinary elevations. Examinations of the blood of those who have become acclimatised, and especially of persons born and living in elevated regions, show that hæmoglobin has increased in amount, and consequently, that the capacity of the blood for oxygen has correspondingly increased. Examinations have also been made of the blood of pigs, sheep, stags, and other animals living at elevations of more than 12,000 feet, and have shown that the blood of acclimatised animals has a much greater capacity of absorbing oxygen than that of unacclimatised animals, amounting in some cases to nearly double the normal amount.

M. Gavarret believes that other causes have to be taken into account in the production of "mountain sickness," especially the imperfect exhalation of carbonic acid from the lungs, and its consequent accumulation in the blood; and I am inclined to this opinion by the identity of the symptoms felt by Mr. Glashier at an elevation of 25,000 feet, with those noticed by me when under the influence of protoxide of nitrogen. At any rate, it is clear that the effects described cannot depend wholly on diminished pressure, but that they are produced by several co-existing causes.

I would also point out that there are other atmospheric conditions in elevated localities, which, to a certain extent, modify the effects of the diminished amount of oxygen contained in the air. These are, the great dryness of the atmosphere, the fierce heat of the sun's rays, and the great cold on snowy mountains, which, to a slight extent, counteracts the effects on the oxygen of diminished pressure.

but which, also, necessitates a greater consumption of oxygen to keep up the temperature of the blood. M. Jourdanet states that the chemical changes, which take place in the blood during its oxygenation, are less marked amongst the inhabitants of "climates of altitude," such as the high table lands of Mexico, and also that all the vital functions are more feebly performed. He also says that the inhabitants of these regions have less muscular strength and power of resisting disease than the residents of countries of lower elevation.

The influence on man, and especially on invalids, of diminished atmospheric pressure, and of the lessened amount of oxygen inhaled at moderate elevations, say of 5,000 feet above sea level and under, has been much considered of late, but as yet sufficient time has scarcely elapsed to efficiently test the results. I will therefore merely say, that great benefit has in some cases accrued to consumptive persons from a winter residence at Davos Platz, and some other places having an elevation of about 4,000 feet, or a little more, above sea level, whilst in other cases, but little good has resulted from the change of residence. The experience of those who have lived on elevated plateaus is, that phthisis is extremely rare in these regions, and other investigations go to show that moisture in the air of elevated regions modifies its beneficial action. If the observations made on the bacteria of phthisis be correct, it is clear that the extreme cold, as well as the diminution of oxygen, has had something to do with the improvement manifested in some patients. The more rapid and deep breathing rendered necessary by the lessened quantity of oxygen taken in at each breath, seems also to assist in the cure. Dr. Weber says that several young persons, who lived from three to twelve months on elevated places, acquired an increased circumference of the chest of from one to two and a half-centimeters. Dr. Williams also believes that the increased size of the chest depends on the change to a higher altitude. The respiratory muscles become hypertrophied, which will account for part of the increased circumference, and the constitution generally improved, but it can scarcely be said that all these result from diminished pressure by the atmosphere. Neuralgia, gout, rheumatism, and most anæmic affections are also said by Dr. Hermann Weber, to be more or less completely removed by a residence in the high Alps. This scarcely seems to be due to atmospheric causes only, as these affections are very prevalent amongst the residents of some elevated valleys of Switzerland, where bad water, dirt, and impure air in

and around their dwellings, are commonly met with, and counteract any good which the afflicted inhabitants might have derived from living at a moderate elevation above sea level. A sudden diminution of atmospheric pressure at any given locality is likely to assist in the escape of ground-air from the soil, and therefore lead to injury to health.

As regards the effects of *increased* barometric pressure, I have but little to say, but it is most probable that the increased feeling of bodily comfort, which we often experience when the barometer readings are unusually high on several consecutive days, is due to the dryness of the air, the direction of the wind, and chiefly to absence of change in the electrical state of the atmosphere, rather than to the increased quantity of oxygen inhaled at each bıeath. On the other hand, the depression and nervous debility so often noticed in this country, with low barometrical pressure, probably depend on the direction of the wind, usually S.W., the excess of moisture in the air, and a disturbance in its electrical condition. When a feeling of exhiliration is noticed at these periods, I believe it will be found that much ozone is present in the air. When pressure is increased either in diving bells, or by compressed air, to the extent of 1½ or 2 atmospheres, the pulse becomes reduced about ten beats per minute, the respirations slightly diminished in frequency, slight singing occurs in the ears, the urine is increased, and the appetite is improved. At greater pressures all these symptoms become more marked, headache often being severe, followed occasionally on the increased pressure being removed, by semi-paralysis, hemorrhages, and even persistent nervous affections.

Temperature.—As regards this element of our inquiry, I may say that experience has shown that, provided man can obtain proper clothing, food, and protection from the weather, he can live and propagate his species in any climate of this globe. The effects of high temperature vary very much, according to the hygrometrical state of the air, as when the heat is great, and the air saturated, or nearly so, with moisture, languor and malaise are felt, often to such an extent as to render every kind of bodily labour most unpleasant; whilst the same, or a higher temperature, with a dry air does not ordinarily produce very depressing effects. The cause is evident; in the former case, there is but little evaporation from the skin, and less than the normal amount of moisture is given off from the lungs, so that the cooling of the body by the evaporation of moisture, which

ordinarily occurs, does not take place, and effete matters, which should be carried off by the skin and lungs, accumulate in the system until they are eliminated by other organs. In this way sunstroke chiefly happens, as under these conditions the temperature of the blood becomes increased, occasionally rising as high as 110 or 111 degs. Fahr., when the myosin of the blood probably undergoes an alteration, preparatory to coagulation, which takes place at 113 degs. Fahr., when the involuntary muscles, as well as the nervous centres, become injuriously affected.

The effects of temperature on man, do not depend so much on the mean temperatures of the months and year, as on the extent of range. For instance, when the day temperature is high, and the night temperature comparatively low, the cold at night assists in procuring refreshing sleep, and restoring the energy of the system which the heat had reduced. The vicinity of the sea or of high mountains also diminishes the injuriousness of a hot climate, as it induces aërial currents every night and morning, by reducing the temperature of the overlying or circumambient air. In this country, a great diurnal range of temperature is often injurious, as during the heat of the day in summer only light clothing is frequently worn, so that when cold sets in during the evening, or a sudden lowering of temperature takes place in the day, a chill is often experienced, followed in many cases by catarrh, pneumonia, or neuralgias.

It is commonly believed that a hot climate is necessarily injurious to Europeans, and shortens their lives considerably, and that the frequent hepatic and digestive derangements, so common in hot climates, are caused only by the increased temperature. This is partly erroneous, as the evidence obtained from the statistical returns of our European army in India show, that sickness and death have been reduced to a large extent by the use of better barracks, and by the good sanitary arrangements, modified dress, and more careful diet, which are now adopted in our army. The well-known marches to Delhi and Lucknow, during the Indian mutiny, and even the late forced marches in Egypt, show that exposure to the mid-day sun may not cause more sickness than a similar march on a hot sunny day in England. Planters, and others in India who ride about a good deal every day, and frequently in the sun, usually enjoy good health, provided the sanitary arrangements in and around their residences are good, and especially if their water supply is uncontaminated by organic matter. There can, however, be but little doubt that a long-continued residence in hot climates is more or less injurious to

Europeans, as their children usually have comparatively feeble frames and lessened vitality, unless sent in childhood to a temperate climate.

These characteristics are also more markedly shown in the next generation, so that, unless crossed with native blood, the race dwindles away and eventually dies out. In cold climates the reverse occurs, as the change even from England is usually attended with better digestion and improved vitality, whilst in very cold, or even Arctic climates, the vigour and strength of Europeans are not impaired if plenty of food, good clothing, and sufficient protection from the weather can be obtained. One reason for this is that during the winter there is but little wind in very cold climates.

Dr. Parkes, at p. 431 of his work on *Practical Hygiene*, makes some very pertinent remarks on the influence of great heat on those who were born in temperate climates. He says that, as yet, no sort of answer has been received as to the influence of high temperature on a race dwelling generation after generation on the same spot. "Does the amount of heat *per se*, independent of food and all other conditions, affect the development of mechanical force and temperature, and the coincident various processes of formation and destruction of tissues? Is there a difference, in these respects, on the resulting action of the eliminating organs in the inhabitants of the equator and of 50 or 60 degs. N. lat.? This is certainly a problem for the future."

During a voyage round the Cape to India, Dr. Belcher made some very careful observations on the temperature of his body, and found that, for each increase of 1 deg. in the mean daily temperature of the air, there was an increase in the temperature of his body to the extent of one-twentieth of a degree. Rattray has also shown that, whilst the number of respirations per minute decreased in the tropics, the quantity of air contained in the lungs increased. It is also well known that evaporation from the skin is increased about 25 per cent., taking one day with another, whilst the amount of excreted urine and of urea is lessened; that digestion is often impaired, and the average number of pulsations of the heart diminished by from three to four beats per minute.

In torrid zones, not only do all the ordinary diseases of temperate climates exist, but diseases of the liver, pulmonary phthisis, fever, cholera, and dysentery prevail to a very great extent, and carry off large numbers of the population. Most of these appear to depend partly on bad food and water, as well as on imperfect sanitary

arrangements. In cold climates, pulmonary phthisis is also one of the most prevalent diseases, probably owing to the bad ventilation of the habitations, especially in winter.

Variations in the pressure and temperature of the atmosphere, exert a considerable effect on the circulation of air contained in the soil, which is called ground-air, and as all the interstices of the ground are filled with air, the more porous the soil, the greater is the amount of contained air. The quantity is sometimes greatly in excess of what is commonly believed, as Professor Hartley states that it has been shown that the bulk of a gravelly soil consists of about one-third air, whilst Pettenkofer says that it varies ordinarily between 3 and 10 per cent., and occupies the space between the stones and particles of sand. If a cesspool or leaky drain-pipes are placed in this kind of soil offensive emanations will escape. These may, especially under variations of temperature and pressure of the air, travel a considerable distance, and make their way into houses, especially when the air of a house is raised by fires to a much higher temperature than that of the ground. Dr. Fyffe mentioned an instance where the foul air of a cesspool was drawn a distance of 27 feet into a house, and I have known it to travel 130 feet along a disused drain. Ground-air must also escape from the soil more quickly when the atmosphere is much warmer than the soil, or when a considerable diminution of barometric pressure suddenly occurs. It is, therefore, important that houses built upon gravel, and especially on made ground, should have the whole of the surface inside the walls covered with six inches of concrete to prevent the entrance of ground-air. Ground-air consists chiefly of atmospheric air intermixed with carbonic acid, marsh gas, and occasionally sulphuretted hydrogen. If there be any putrefying organic matter in the soil, ground-air will also be contaminated with injurious gases resembling sewer emanations.

The ground-air is also displaced by rain, which raises the level of the ground-water, and also causes a rapid escape of air from the interstices of the soil. Winds, by their drying action on the surface of the soil, also assist in producing movements in the ground-air and in the level of ground-water. Fevers, cholera, diarrhœa, and dysentery are said to be caused by the escape of ground-air into houses.

The direct action of *Rain* upon the human body is not very marked in England except by inducing colds, but in hot climates it is believed to be an active cause of dysentery and malarial fevers.

Rain does not directly act to any great extent on the atmosphere, except by absorbing ammonia, organic matters, acid and empeyreumatic vapours, as but little moisture is given off during its passage through the air. The humidity of the air depends chiefly on the amount of evaporation that occurs from the sea, soil, and vegetation. Rain, however, exerts a great influence on the moisture contained in the soil, and on the ground-water, and thus affects materially the well-being of man, as it is found, that when the ground-water has persistently a level of only five feet, or less, from the surface, the locality is unhealthy, and when it is more than fifteen feet it is, *cæteris paribus*, healthy; also that a fluctuating level, especially if the changes are sudden and great, generally leads to ill-health amongst those residing on the spot.

It has been pointed out, that outbreaks of typhoid fever have frequently occurred soon after heavy falls of rain succeeding drought, which are believed to have originated from the infectious particles of typhoid excreta being washed into wells used for drinking. Endemics of scarlet fever have also been traced to well-water which has been thus contaminated. The distance of the level of ground-water from the surface, varies very much more in hot than in temperate climates, owing to the difference in the rainfall. Thus, in India, during the rainy season, the ground-water level in the same locality is only a few inches, whilst in the hot season it is as much as 17 or 18 feet below the surface. The effects of rain depend very much on the soil. On clayey ground, rain produces a much greater degree of saturation of the atmosphere than in porous soils, as well as a higher level of ground-water, causing dampness of the basements of houses. Decomposition of organic matters in the soil is also hastened, especially in hot weather, by heavy rainfall, with consecutive injury to health. Colds and coughs, rheumatism, heart disease, neuralgia, and, in hot climates, fever, are the affections most frequently found in these localities. The effects on the lungs of damp ground has been well shown by one of our former Presidents, viz., Dr. Buchanan, in his reports to the Medical Officer of the Privy Council in 1866—1867. He stated that phthisis, using the word in its most extended sense, occurs more frequently on a damp than a dry soil, and numerous reports have since then been published, showing that effective drainage of the land, and consequent rapid carrying away of the rain-water, has been followed by a diminution in the mortality from these diseases. Pettenkofer and Seidel also pointed out the

relations between outbreaks of typhoid fever, and the rise and fall of the ground-water, the greatest mortality at Munich from this fever having occurred when the ground-water was lowest, and therefore, after periods of drought. These observations, however, have not been confirmed in England; indeed, Dr. Buchanan thinks that the relations between the height of the ground-water, and the prevalence of typhoid fever at Munich, depended upon the greater impurity of the drinking water which was derived from wells. In any case, it is almost certain that some specific germs must have found their way into the well-water, and thus caused the outbreak. Pettenkofer holds similar opinions as regards cholera.

Varying conditions in the *Humidity* of the air naturally affect the comfort and well-being of man. It is not so much the absolute, as the relative humidity of the air with which we are concerned; that is to say, the proportion of moisture which the air holds, as compared with what it is capable of holding, saturation being represented by 100. This varies according to the temperature. For instance, one cubic foot of air, when saturated with aqueous vapour, contains at 40 deg. Fahr., 2·86 grains of water; at 50 deg. Fahr., it holds 4·10 grains; at 60 deg. Fahr., 5·77 grains; at 70 deg. Fahr., 8·01 grains; and at 90 deg. Fahr., as much as 14·85 grains. With a temperature of 70 deg. Fahr., and 75 per cent. of saturation, evaporation from the skin proceeds rapidly, especially with air in motion, although the atmosphere contains more moisture than when saturated at 60 deg. Fahr. With a saturated atmosphere, there exists a tendency towards a rise in the temperature of the body, especially in warm climates, causing a most oppressive feeling of malaise. Warmth and excessive humidity are, however, less injurious to man than a low temperature with great humidity, unless there be a stagnant state of the air with the former, when intermittent fevers, dysentery, and other tropical diseases, are usually prevalent, and the feeling of lassitude is almost unbearable. This feeling is particularly noticeable in the zone of calms.

As regards the effects of *Winds* on the body, I have already referred to their cooling action, by causing increased evaporation. Strong cold winds abstract heat by their direct action, and are therefore, injurious in very cold climates, where however, they are comparatively rarely met with. Their cooling effects depend on the temperature, hygrometrical condition, and velocity of the wind, so that I cannot assign any special value to winds in England, and will only say that rheumatism, colds, and neuralgias, are frequent

during the prevalence of easterly winds, whilst a feeling of increased bodily vigour is generally noticeable with northerly and north-west winds. The affections mentioned, however, do not depend merely on the temperature and motion, but on the varying amounts of moisture which winds contain, according to the surfaces they have passed over before reaching our shores.

Wind influences to a considerable extent all the other meteorological phenomena. For instance, the pressure of the atmosphere, and the temperature, depend partly on the direction of the wind, as winds from the north are usually accompanied by a high state of the barometer, and in winter with a low temperature. We must also remember, that equatorial winds bring warmth from the equator, whilst Polar winds convey cold to warmer climates. The humidity of the air also depends partly on the wind, that is to say, that it varies considerably according to the surface, whether of water, earth, ice, or sand, over which the wind has passed. It is also well known that the largest amount of rainfall occurs in this country when the wind blows from the south and south-west, and especially from the latter quarter. As some statistical information on this point may be interesting, I append a table, which I have calculated from a paper by Mr. Strachan,* to show the proportionate number of observations on 3,148 days upon which rain fell with different winds; and another from a paper by Mr. Glaisher,† showing the number of hours during which the wind blew from different points of the compass during 8,765 consecutive hours.

Wind.	Percentages of Observations with rain.	Percentages of Observations without rain.	No. of hours during which the wind blew.
N.	6·5	10·0	9·4
N.E.	12·3	10·5	11·6
E.	11·0	12·3	6·9
S.E.	4·9	3·7	6·5
S.	14·2	7·2	7·3
S.W.	30·5	17·2	31·2
W.	15·7	25·7	14·3
N.W.	4·0	10·3	6·4
Calm	0·9	3·1	6·4
	100	100	100

We see from this, that out of 100 observations of wind with rain, in 44·7 instances the wind was south or south-west; that out of

* Proceedings of Meteorological Society, 1870.

† Quarterly Journal of the Meteorological Society, Vol. I.

100 observations of wind without rain, the wind came on 24·4 occasions from the same quarter, and on 25·7 occasions from the west; and from Mr. Glaisher's table, that the wind blew from the south and south-west 38·5 hours out of each 100 hours during the ten years 1861-70, and 14·3 per cent. from the west.

Ozone.—Although a great deal has been written on the effects of ozone on man, and some of the diseases from which he suffers, yet but little is really known concerning it. Thus some recent experiments have been carried out by Professor Binz, of Bonn, with ozonised air which produced very different effects on several persons. In some the breathing of ozonised air caused sleep, but in varying degrees, whilst in others it did not in any way affect the cerebral functions. Twitching of the muscles of the forehead and eyes, and general depression were produced in some, whilst in others it caused a sense of comfort whilst breathing, so that the effects were very dissimilar, and may partly have been caused by the imagination. This constituent of the air is augmented by violent winds, and especially by thunderstorms, and is met with in England chiefly at the seaside, and in country places, including the outskirts of cities, and but rarely in the centre of cities. About twenty-five years ago, Mr. Burge, of Fulham, and myself, made daily ozonometrical observations with the corresponding halves of ozone papers, and we found, that when ozone was met with at Fulham there was none at Hackney, and *vice versâ*, owing to the ozone being destroyed by passing through the air of London. It must not, however, be taken for granted, that the change in colour of the ozone paper always depends on ozone, as any oxydising gas will have the same effect. For instance, the deepest tint I ever saw on my ozone papers, occurred on the night of the Peace rejoicings, when a large quantity of fireworks was let off about a mile from my station, the wind blowing from the place where the fireworks were displayed. Mr. Glaisher also stated in his report on the cholera epidemic of 1848, printed in the Registrar-General's report, that ozone disappeared during the prevalence of this disease in London, but was again observed on its decline. Excess of ozone was stated by Schonbein to induce a tendency to diseases of the lungs, and especially to phthisis, but subsequent observations have not confirmed this statement. There is, however, but little doubt that it exerts an active oxydising action on any organic matter which may be in the air, and is therefore, usually absent in close, confined places, where the air contains excess of

organic matter. Also that when in excess, it causes a feeling of comfort, especially in those not accustomed to inhale an atmosphere containing much ozone.

Having now considered that part of my subject which refers to the general effects of meteorological phenomena on man, I shall now allude with great brevity to their relations to some of the individual diseases with which man is afflicted. The obstacles to which I referred in my preliminary remarks, as preventing the physicians of olden times accurately determining the relations between atmospheric vicissitudes and disease, were more insuperable when the attempt was made as regards special diseases. Even in more recent times, Sydenham after bestowing much time and consideration on the subject, concluded that his time and trouble had been lost. Van Swieten, after keeping a record of barometrical and thermometrical readings for ten years, arrived at the conclusion that he was no wiser as to the effects of atmospheric variations on epidemic diseases, than when he began. Ramazzini, after devoting considerable time and labour to the matter, said that he could see no constant relations between the changes of the atmosphere and disease, and was as ignorant as ever at the termination of his work; and the same may be said as to the investigations of Huxham, and many others.

I do not propose to discuss the manner in which these, and other observers attempted to solve the question, but it is evident that if we desire to obtain reliable results, the subject must be attacked in a systematic manner, and that one or more elements of the inquiry must be uniform and definite. For instance, if population be taken as a basis, corrections must be made for increase or decrease. The usual plan is to take the two last censuses as a basis, but these should be checked; if the locality under discussion be small, by ascertaining the number of new houses erected, or of old dwelling-houses converted into offices or warehouses, or pulled down during the period under consideration. This can be ascertained from the rate-books. Again, the condition of the population has to be considered. For instance, the death rate from small-pox in 1871-80, amongst the poorer residents of Hackney, excluding those living near the Homerton Hospital, was 1.60 per 1,000, against only 0.21 amongst the richer classes. The meteorological conditions under which they lived were the same, but other circumstances caused the great difference. It is therefore clear, that poverty, and its surroundings, must be taken into consideration when limited areas are

under investigation. The mean age of the residents of small districts must also be considered. If however, we take all London, the probability is that our conclusions, after allowing for increase of population, will be sufficiently correct, as, although the population is always increasing, yet the proportions of rich and poor, and of the working and other classes, remain comparatively unchanged.

Other important matters for consideration are, the initial periods we should take for the inquiry, and the time we should allow to elapse after the occurrence of the weather discussed, and the registration of disease or death. As there is not a sufficiently extensive record of disease ready for our use in London, the inquiry is usually limited to the deaths. If we are comparing meteorological observations with deaths from summer diarrhœa, the interval between the two should be shorter, say, than that for scarlet fever. Again, as regards the last-named disease, the duration of illness varies much in different epidemics, according to the prevailing complications. Thus, in the epidemic of 1848 in London, which I specially investigated, there was an unusually large percentage of deaths from dropsy at a late period of the disease. This can scarcely be allowed for, and will not modify the conclusions to any appreciable extent, if the investigation be spread over several years.

In the Registrar-General's annual summary for 1880, it is stated that the highest mortality from summer diarrhœa, corresponds with the week of highest temperature; whilst the greatest mortality from inflammatory diseases of the respiratory organs, is registered three weeks after the minimum temperature.

The next matter for consideration, is the number of the meteorological elements which we should embrace in our inquiry. Usually, as being the most potent of all, the effects of temperature alone are discussed; but, as we have shown that other meteorological phenomena affect the human body, as well as temperature, it is quite clear, that if we limit ourselves to this one element of inquiry, all we can say is, that the mortality from a certain disease decreased or increased as the temperature rose or fell. Is this enough? Scientifically it is not, but for practical purposes it may be sufficient.

I trust that I shall not appear egotistical, if I refer to some papers I have published, on what has been termed Medical Meteorology. The first of these appeared in the *Med. Times* in 1848-49, when I very carefully investigated the relations between the mortality from scarlet fever and meteorological phenomena, that is to say, temperature, humidity, and varying electrical states of the air, and arrived

at the following conclusions. Firstly, that a mean monthly temperature below 44.6 deg., is adverse to the progress of scarlatina; whilst a mean temperature above 44.6 deg., is coincident with an increase in the mortality from the disease. Secondly, that the greatest mortality from scarlatina, occurred in the months which had a mean monthly temperature above 44.6 deg., and below 57.0 deg. Fahr. Thirdly, that during the nine years 1839-48, the greatest increase in the mortality of one month, as compared with that of the next, happened when the mean monthly temperature was the same as that just mentioned; and the greatest decrease in the comparative monthly mortality, happened when the mean temperature of the month was below 40.0 deg. Fourthly that the increment in the mortality, did not occur in the same ratio with the increase of temperature, nor did the diminution in the temperature correspond with the ratio of decrease in the number of deaths; but the closest correspondence occurred in the months of December, January, and February, when the mean monthly temperature was 40.0 deg. or below.

As regards the effects of humidity on scarlet fever, I found that the comparative mortality was, with the exception of the month of March, lower in those months in which the degree of humidity was above the average of the month. In March, there was a higher comparative mortality when the humidity of the atmosphere was *plus* than when it was *minus*. These results are shown in detail in the following table:—

	Comparative Mortality, Humidity of the Air being	
	Plus.	Minus.
January	57	58
February	91	190
March	99	83
April	80	90
May	108	129
June	106	137
July	112	121
August	105	109
September	114	140
October	120	121
November	85	99
December	77	77

By comparative mortality, I mean the mortality of one month when compared with that of the preceding, say of February compared with that of January, which would be termed the comparative mortality of February.

As regards *Electricity*, I found that when frequent indications of its existence were manifested, the comparative mortality from this disease, was below the rate for those months in which it was in an almost passive condition. I therefore concluded, that an active state of the electricity of the air, tended to diminish the spreading of scarlatina. The whole of these conclusions apply to London.

In another paper, read before the Meteorological Society in 1859, and published in their report for 1859-61, I referred to the connection between meteorological changes, and the mortality from inflammatory diseases of the lungs, diarrhœa, and phthisis, and, in a subsequent paper published in 1862, which was read before the same Society, I gave the percentages of deaths from "all causes," "inflammatory diseases of the lungs," "fever," and "diarrhœa," during the three years 1859-61. The following table gives a summary of the results, and shows that the results then obtained correspond with those stated by later inquirers.

Percentage of Deaths in the Metropolis, 1859-61.

	Mean Weekly Temperature.	Below 35 deg.	35 to 40 deg.	40 to 45 deg.	45 to 50 deg.	50 to 55 deg.	55 to 60 deg.	60 to 65 deg.	65 to 70 deg.	70 to 75 deg.	Total.
Percent. of Deaths.	All Causes	14.2	11.9	11.3	9.8	9.3	8.9	9.7	11.0	13.9	100
	Respiratory Organs	25.8	17.8	14.8	11.9	8.3	6.5	5.4	4.5	5.0	100
	Fever	9.2	11.9	9.9	10.6	10.9	9.2	10.9	12.2	15.2	100
	Diarrhœa	1.4	1.7	1.5	1.5	3.1	5.8	13.4	27.3	44.3	100

The statistical investigations, however, of Mr. Buchan and Dr. Mitchell, published in the *Journal of the Scottish Meteorological Society* for 1877, show that, as regards scarlet fever, the curve for New York is entirely opposed to that for London. Thus, the lowest death-rate from this disease, happens in New York between the end of July and early in October, which corresponds with the period of rise and greatest mortality in London. Again, the curve for London falls in February, March, April, and part of May, thus attaining its lowest point when the mortality is greatest in New York. We are therefore, driven to the conclusion, either that the same meteorological changes which appear to increase the disease in London decrease it in New York; or that the mortality per cent. of

attacks, is greater at one period of the year than at another. Similar opposing curves are noticeable as regard whooping-cough. These are by no means satisfactory results to have arrived at after so much labour. On the other hand, the curves of mortality from small-pox, measles, diphtheria, typhoid fever, diarrhœa, phthisis, bronchitis, pneumonia, heart disease, and apoplexy, closely correspond in both of these great cities.

The curves for London of temperature and of deaths from "all causes," do not correspond, as whilst the former rises continually up to July and the first week in August, and then falls sharply, with the exception of the first fortnight in December, until the end of the year; there are two elevations and two depressions in the latter curve. Starting from the lowest part of the *mortality* curve, which occurs in the month of June (during which the weekly mean temperature rises from 55 to 61 degs. Fahr.), a very rapid ascent takes place in July, at the end of which the mean weekly temperature is 62 degs. Fahr. The curve then remains almost level for a few days, and rapidly falls again to the first week in October, when the mean weekly temperature is about 53 degs. Fahr. It then ascends rapidly to the end of December, when the highest period is reached, and, with slight oscillations, it remains high to the end of March, and then rapidly descends to its lowest point in June. The death-rate, therefore, describes one long ascending or elevated curve from the first week in October to the end of March, when the weekly mean temperature ranges between 54 degs. Fahr. in October, 35·8 degs. in January, and 45 degs. at the end of March. The extremely sharp ascending curve in July, is caused chiefly by the deaths from diarrhœa, whilst the almost equally sharp ascending curve in November arises, from the great mortality caused by acute diseases of the lungs. The relations between the excess of mortality from diarrhœa, and the increased temperature are so marked, as to show that directly or indirectly the disease depends on the increased heat. The summer in New York is hotter than in London, by as much as 12½ degs. Fahr. in July, and 10½ in August, so that, as might have been expected, the deaths from diarrhœa then rose to as much as 346 per cent. above the mean for New York against 279 in London, during the seven years 1871-77. It is, however, very probable that the large number of cesspools, the bad drainage and scavengering of New York have a great deal to do with the excess of deaths from diarrhœa. It was reported by the Medical Officer of Health that accumulations of house refuse and heaps of filth

remain untouched for weeks and even months, which, with cesspools filled with human excreta, must necessarily, when exposed to great heat, give off emanations favourable to severe attacks of diarrhœa. Although the curves generally correspond, as regards bronchitis in London and New York, yet there are considerable differences during the winter months in the rate of increase in these two cities. The mean monthly winter temperatures in New York are much lower than in London, being 8·8 degs. in December, 8·7 degs. in January, 10·1 degs. in February, and 6·4 degs. in March, below the London mean temperature; but the mortality curve only shows an increase of 43 per cent. above the mean, against 85 per cent. for London; the total fluctuations in New York representing 86 per cent. against 148 in London. Now, as the winter is so much colder in New York, and the oscillations of temperature so much greater, why is the difference in the death rate from bronchitis so large in these cities? I believe the reason to be that the air of New York is much drier than that of London, so that there is very little of the "raw weather," which makes the London winter so very unpleasant and unhealthy. Fog also in London, often increases the number of deaths from lung diseases to a very great extent.

I have already alluded to the great difference in the curves for whooping cough and scarlet fever in London and New York. In the last named city there are two maxima and two minima for whooping cough; the former occurring in February and March, and again in August and September, whilst the minima happen in June and November. In London there is only one maximum, which lasts from the end of December to the end of May, during which period the mean weekly temperature ranges from 40 degs. down to 36 degs. in January, and 54 degs. in May. The mean temperatures in New York during the months just mentioned, are so different, that the rate of mortality from whooping cough, can have but little relation to the mean temperature, at any rate in that city.

Although the curve of typhoid fever, as already stated, has a close similarity, it is by no means identical in both cities, as the maximum occurs in September in New York, when the mean monthly temperature is 64·0 degs., whilst the highest occurs in London in November, when the mean temperature is 40·6. This difference in the temperature is very great. Taking, therefore, whooping cough, typhoid fever, and scarlet fever, into consideration, it is evident that other meteorological conditions, than those of

temperature, must be in operation to produce these different results. As regards scarlet fever and typhoid, death arises more often from complications and sequelæ, than from the febrile attack, which may perhaps account for some of the differences just mentioned. The well-known periodical occurrence of epidemics of scarlet fever, small-pox, and other zymotic diseases, does not appear to depend on meteorological phenomena, but chiefly, if not entirely, on the number of persons liable to the disease then living in the infected locality.

Considering the intimate relations known to exist between bacteria and disease, I do not think I shall be digressing, if I refer to the influence of temperature on these micro-organisms. In a paper which I read in 1880 before this Society, I pointed out that whilst some of the living forms in sewage ceased to move at a temperature of 130 deg. Fahr., the majority, especially the micrococci and bacteria, continued in action up to 140 deg. Fahr., when almost all ceased to move. These observations correspond pretty well with the experiments of Vacher and others on vaccine lymph, which lost its infective power at 150 deg. Fahr. Bacillus anthracis is said by some authors to be killed by a temperature of 131 deg. Fahr. continued for some time, whilst the hay-bacillus requires a considerably higher temperature for its destruction. Drs. Koch and Wolffhügel however state that bacteria are not killed by a lower temperature than 212 deg. continued for an hour and a half; and that a temperature of 285 deg. is required to destroy the spores of bacillus anthracis. Mr. Crace Calvert also made a similar statement as to the bacteria met with in liquids containing decomposed meat. Dr. J. C. Ewart states that in a recent outbreak of fever in Aberdeen, characterised by frequent relapses on the second day, he ascertained that all the patients were supplied with milk from one dairy, and that on examining the milk, he found numerous bacilli and spores resembling those of bacillus anthracis. That these being introduced under the skin of some rats caused death, but that by cultivation, the infective power of the bacilli became gradually less active, and subsequently, when kept at a temperature which prevented the formation of spores, the power of infection became lost. Unfortunately for my purpose, the temperature is not mentioned.

There are, so far as I know, but few observations as to the temperature and other meteorological conditions which induce the growth of these organisms, so as to cause endemic or epidemic diseases.

Dr. Loomis, of America, states that the bacillus malariæ cann developed until the mean daily temperature reaches 58 deg. F and unless there be a certain amount of moisture in the air, in subsoil, and surface of the ground. Also that malarial diseas not become epidemic until the mean daily temperature reache deg. Fahr. Sir J. Fayrer says that a temperature in excess o deg. Fahr., and the presence of moisture, are requisite for the d lopment of malarial poison. Klebs and Tomassi Crudeli say th mean temperature of 68 deg. Fahr. or above is required for growth of the bacillus malariæ, and that when this is reached, quantity of this bacillus can be found in the soil of the Pon marshes and the Campagna. Koch states that the bacillu tubercle requires a temperature of above 86 deg. Fahr. for its pagation, and that therefore, save in hot climates, it cannot incr except in an animal. M. Pasteur showed, about two years si that if fowls were inoculated with the bacillus causing splenic fe they did not contract the disease until the temperature of t blood was artificially reduced ; and M. Gibier has successfully culated frogs with the same virus, after their temperature had raised by immersion in warm water, although they were previo insusceptible to its action. The bacillus which is met with in wa closets when diarrhœa is prevalent, is said not to be met with u the mean daily temperature is in excess of 60 deg. Fahr., and certain that diarrhœa is rarely prevalent in London until the w of the Thames reaches a mean temperature of 62 deg. Fahr. difficulty, however, as to the water-closets is that bacilli are fo there at times when diarrhœa is not prevalent ; and the same be said as regards the stools of infants.

The influence of light on the growth of bacteria is very mar Thus, in 1877, Dr. Downes and Mr. Blunt proved that strong light succeeded in arresting the development of bacteria ; and fessor Tyndall has corroborated their statements, and showed whilst one set of flasks containing infusions, were speedily conta nated with numerous bacteria if kept in the dark, others simil prepared did not contain bacteria when they had been expose the sun's rays during three days, showing that the arrest of deve ment continued during the night.

In conclusion, I have to apologise for the sketchy character of address, but the time at my disposal does not allow of an exhaus discussion of any part of the subject.